CLAIMS:

1. A method of automatic fault diagnosis including:

for each of a plurality of components of machines, carrying out the steps of:

5   for at least one possible fault in the component:

calculating a total fault symptom strength value from measured data indicating the strength of the fault; and

if the total fault symptom strength value lies above a predetermined value for that fault, recalling stored data relating to the total fault system strength value as a

10   function of time, fitting the stored data to a trend line and predicting the time when the total fault symptom strength value will exceed a predetermined value, selecting a message based on the total fault symptom strength value and the predicted time, and outputting the selected message.

15   2.   A method according to claim 1 wherein the reduced dataset is stored in a database and the method further includes automatically taking measurements of the component when a predetermined condition occurs, calculating new reduced data, testing whether the new measurements represent a significant change on the reduced data stored in the signature database, and storing the new reduced data in the

20   database if the step of testing indicates a significant change.

3.   A method according to claim 2 wherein the method further includes classifying the operation state of the data, comparing the new reduced data with reduced data from the same operation state and storing the new reduced data in the

25   database indexed by the operation state.

4.   A method of automatic fault diagnosis for machinery having a plurality of components, based on a reduced dataset calculated from data measured on the machinery, the method comprising:

30   for at least one machine component, and for at least one fault that may occur in that component, carrying out the steps of:

calculating for each of a plurality of symptoms for indicating that fault, a symptom value as a function of the reduced dataset calculated from measured data;

combining the symptom values to give a total fault symptom strength value indicating the strength of the fault; and

carrying out fault processing if the total fault symptom strength lies above a predetermined value.

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5.   A method according to claim 4, including classifying the operation state of the machine and recording the classification of operation state together with the measured data in the reduced dataset and calculating the symptom values from data from selected classification states.

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6.   A method according to claim 5 wherein in addition to a symptom value representing the relative magnitude of deviation of measured values in a operation state from baseline values in an operation state a symptom stre representing the size of the measured values is calculated for each of the symptoms.

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7.   A method according to claim 4 wherein the total symptom strength of a fault is calculated from a fuzzy minimum of symptom values corresponding to the fault.

8.   A method according to claim 4 further including, if the total fault symptom
20   strength for the fault lies below a first predetermined value, carrying out no further processing for that fault, and if the total fault symptom strength lies above the first predetermined value switching, for the fault, from a first mode in which the value of the total fault symptom strength is not recorded on an ongoing basis to a second mode in which the total fault symptom strength is recorded on an ongoing time series
25   basis.

9.   A method according to claim 4 further comprising automatically starting a routine for checking the faults of a component at regular intervals, the routine calculating the total fault symptom values, and if necessary carrying out fault
30   processing for each of a plurality of faults that may occur in that component.

10,   A method according to claim 4 wherein the reduced dataset is stored in a database and the method further includes automatically taking measurements of the

component when a predetermined condition occurs, calculating new reduced data, testing whether the new measurements represent a significant change on the reduced data stored in the signature database, and storing the new reduced data in the database if the step of testing indicates a significant change.

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11.   A computer program system recorded on at least one data carrier including code for causing a computer system to carry out the steps of:

for each of a plurality of components of machines, carrying out the steps of:

for at least one possible fault in the component:

10   calculating a total fault symptom strength value from measured data indicating the strength of the fault stored in a database; and

if the total fault symptom strength value lies above a predetermined value for that fault, recalling stored data relating to the total fault system strength value as a function of time, fitting the stored data to a trend line and predicting the time when

15   the total fault symptom strength value will exceed a predetermined value, selecting a message based on the total fault symptom strength value and the predicted time, and outputting the selected message.

12.   A computer program system according to claim 11 wherein a machine

20   component object is provided for each of the machine components for which autodiagnosis is performed.

13.   A computer program system according to claim 12 wherein the program includes a number of general object classes corresponding to different types of

25   machine component and the machine component objects are specific instances of the general object class corresponding most closely to the machine component, which specific instances inherit code relating to possible faults in the type of machine component from the general object class.

30   14.   A computer program system according to claim 11 including

code for automatically taking measurements of the component, calculating new reduced data, testing whether the new measurements represent a significant change on the reduced data stored in the database, and storing the new reduced data

in the database if the step of testing indicates a significant change.

15.   A computer program according to claim 14 further including code for classifying the operation state of the data, comparing the new reduced data with reduced data from the same operation state and storing the new reduced data in the database indexed by the operation state.

16.   A computer program system recorded on at least one data carrier including code for causing a computer system to:

        for a plurality of faults that may occur in one or more machine components, carrying out in turn for each in turn the steps of:

        calculating for each of a plurality of symptoms for indicating that fault, a symptom value as a function of data stored in a database, the data being reduced data calculated from measured data;

        combining the symptom values to give a total fault symptom strength value indicating the strength of the fault; and

        carrying out fault processing if the total fault symptom strength lies above a predetermined value.

17.   A computer program according to claim 16, further comprising code for classifying the operation state of the machine and recording the classification of operation state together with the measured data in the reduced dataset and calculatng

18.   A computer program according to claim 16 further including code for determining if the total fault symptom strength for the fault lies below a first predetermined value, and if so carrying out no further processing for that fault, and otherwise switching, for the fault, from a first mode in which the value of the total fault symptom strength is not recorded on an ongoing basis to a second mode in which the total fault symptom strength is recorded on an ongoing time series basis.

19.   A computer program according to claim 16 further comprising code for starting a routine for checking the faults of a component at regular intervals, the routine calculating the total fault symptom value, and if necessary carrying out fault

processing for each of a plurality of faults that may occur in that component.

20.   A computer program according to claim 16 further including code for automatically taking measurements of the components when a predetermined condition occurs, calculating new reduced data, testing whether the new measurements represent a significant change on the reduced data stored in the signature database, and storing the new reduced data in the database if the step of testing indicates a significant change.

21.   A system for automatically outputting a fault diagnosis for at least one possible fault, including code for carrying out the method of:
        for each of a plurality of components of machines, carrying out the steps of:
        for at least one possible fault in the component:
        calculating a total fault symptom strength value from measured data indicating the strength of the fault stored in a database; and
        if the total fault symptom strength value lies above a predetermined value for that fault, recalling stored data relating to the total fault system strength value as a function of time, fitting the stored data to a trend line and predicting the time when the total fault symptom strength value will exceed a predetermined value, selecting a message based on the total fault symptom strength value and the predicted time, and outputting the selected message.

22.   A system for automatically outputting a fault diagnosis for at least one possible fault, including code for carrying out the method of:
for a plurality of faults that may occur in one or more machine components, carrying out in turn for each in turn the steps of:
        calculating for each of a plurality of symptoms for indicating that fault, a symptom value as a function of data stored in a database, the data being reduced data calculated from measured data;
        combining the symptom values to give a total fault symptom strength value indicating the strength of the fault; and
        carrying out fault processing if the total fault symptom strength lies above a predetermined value.

23. A system for automatically outputting a fault diagnosis for at least one possible fault, including a hierarchical database including a number of general object classes corresponding to different types of machine component and the machine component program objects are specific instances of the general object class corresponding most closely to the machine component, which specific instances inherit code relating to possible faults in the type of machine component from the general object class, the machine component program object including code for determining whether specific faults occur.

24. A system for automatically outputting a fault diagnosis including

a signal processing unit for measuring data and recording the measured data in a database; and

a server for testing, for a plurality of fault conditions corresponding to one or more components, whether the measured data stored in the database indicates those faults, and outputting a text message identifying any faults detected and the likely time before the fault becomes critical.

25. An automatic machinery fault diagnostic method and procedure for machines or one or more components thereof, characterised by using a Machinery Fault Class Library including references to specific signatures calculated from signals acquired from sensors placed at specific locations on said machine.

26. A procedure according to claim 25, characterised by said fault class library including references to specific signatures for each fault class.

27. A procedure according to claim 26, characterised by using a combination of unique fault signatures measured at specific machine states.

28. A procedure according to claim 27, characterised by determining the machine states by virtual measurements in a signal processing unit and/or acquired from external systems.

29.   A procedure according to claim 27, characterised by determining the machine states by virtual measurements in a signal processing unit by using a predetermined monitoring strategy as to when and how often to collect data.

5   30.   A procedure according to claim 25, characterised by using an event controlled data communication strategy from said signal processing unit for communication with a server, only data including new information being communicated to said server.

10   31.   A procedure according to claim 25 using a fault class method in terms of a formal diagnostic language/syntax comprising mathematical operations, logics (crisp and fuzzy and descriptive decision theory).

32.   A procedure according to claim 25, characterised by using one diagnostic
15   fault class method per signature per component per machine,

33.   A procedure according to claim 32, characterised by instantiating a diagnostic fault method object (local instance in a physical object) per signature, per component, per machine, adapted by entering machine specific information, such as
20   type of bearing, number of teeth of gears, etc. during configuration.

34.   A procedure according to claim 25, characterised by a diagnostic class method being editable in terms of modifications and expansions; modifications being instantaneously applied to associated object methods.
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35.   An auto-diagnosis supervisor parallel process including providing diagnoses for all fault class methods per signature, per fault, per component, per machine at selective intervals/events and combined symptoms and severity for all fault object methods per measured signature stored in the database.
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36.   An auto-diagnosis supervisor parallel process according to claim 35, characterised by combining all symptoms and symptom severity per fault in one total symptom.

37.   An auto-diagnosis supervisor parallel process according to claim 35, characterised by storing in the database the history of TOTAL SYMPTOM for fault development prediction.

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38.   An auto-diagnosis supervisor according to claim 36 for issuing three diagnostic messages for TOTAL SYMPTOM STRENGTH:
  I. Fault Detection;
  II. Fault Prediction and
10   III. Critical Fault Development

39.   An Auto-Diagnosis Supervisor according to claim 37 for providing prediction for fault TOTAL SYMPTOM development at any moment after level II, estimating data for level III events, said Method being based on modelling by Regression
15   Analysis of Total Symptom Strength history to predict future development and to provide Statistical Confidence for this Prediction.

40.   A fault object message containing recommendation messages to the user of the system for the three TOTAL SYMPTOM levels, said message being locally
20   adapted and edited by a local system manager.